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CONSTRUCTION AND PRELIMINARY STUDY OF TUNABLE DYE LASER,(U)
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FOREIGN TECHNOLOGY DIVISION

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By

Chu Yi-min, Shih Chien-ping and Yen Hsiao-pai

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Construction and Preliminary Study of Tunable Dye Laser

By
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1. Introduction

Generally the oscillatory wave length of a laser is not variable, so its application is greatly limited. But a tunable dy laser can continuously vary its oscillatory wave length in a great range in the vicinity of an area where it is visible, and it has been, therefore, applied to the following areas.

(1) Isotope Separation. Using the difference of wave length of sharp absorption spectra among isotopes, the wave length of a laser can be adjusted in tune with absorption spectrum of only one isotope. Then it can be selectively stimulated and made separate from other isotopes. This method can be used to separate U^{235}, and, according to some statistics, it can save cost by 90%, compared with the traditional vapor diffusion method.

(2) Pollution-finding Radar. To the incident light of different wave length, different materials show strong action of diffusion or absorption. So a laser, of which the wave length can be adjusted, can be used to find the composition and density of the atmospherically polluted materials.

(3) Agricultural Seeding and Medical Application. The chromosome in a cell is very sensitive to some wave length of the outside light. Under the action of a light with such a wave length, genetic variation will occur obviously. For instance, in an experiment of laser seeding, the Department

of Biology of this University uses tunable dye laser with a range of 5600Å - 6200Å emitting light to shine on the rice seeds. The variation rate is higher than the Ar^+, CO_2, He - Ne laser.

(4) Spectroscopy. The light emitted from a tunable dye laser is always of unicolor and directionality. It is strong and can freely select its wave length. So it is an ideal light source for spectral analysis. When it is used in atomic absorption spectrum, fluorescence spectrum or Raman spectrum, it can help to promote the sensitivity of the analysis and have a measurement with high accuracy in a short period of time.

Using four different kinds of dyes, we obtained laser emission, of which the wave length can be freely selected in a range of 5300Å - 7000Å, and found the relationship between the denisty of dyes and the adjustable ranges.

2. Basic Principles and the Structure of Laser

Diagram 1 is a typical diagram of the molecular energy level of organic dyes. What the laser used is corresponding fluorescence $S_1 \rightarrow S_o$ which is allowed to leap forward. Because the width of fluorescence spectrum can reach several hundred angstrom, the oscillatory wave length can be freely selected in a certain range.

The instrument used to select oscillatory wave length can be a grating, prism, calibrator and the like. We chose to use a reflecting grating of 1200 tiao/mm.* We put the adjustable grating at a position that can make

* tiao is a Chinese transliteration which literally means a strip[illegible]

only the radiation which selects wave length radiate along the direction of the laser axis and oscillation can occur on the selected wave length.

The life-span of S_1 state is rather short. If the number of particles between S_1 and S_0 can be reversed, there must be sufficient stimulation. In order to save the laser lost caused by triplicity light absorption, we chose to use pulse N_2 laser as stimulation source, which can be accelerated quickly.

The structure of tunable dye laser can be seen in Diagram 2.

N_2 laser: laser wave length is 3371Å; pulse power is 1 megawatt; pulse width is 10 nanosecond; and repetition rate is 50 times/minute.

Quartz dye box: Length is 2 centimeter; thickness is 0.5 centimeter; and heigth is 2.5 centimeter.

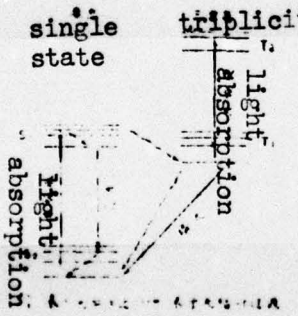

Diagram 1 Diagram of molecular energy level of dyes

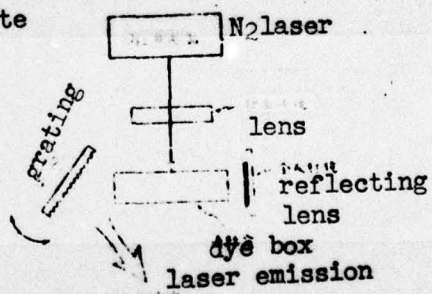

Diagram 2 Tunable dye laser

3. Dyes and Adjustable Ranges

According to the order of sodium fluorescein, rhodmine 6G, rhodamine B

and methyl phenol purple, laser emission of any wave length in the range of 5350Å ~ 7000Å can be obtained. The solvent of the dyes is alcohol and the concrete data can be seen in Table 1.

Table 1

Dyes	Density (mole/liter)	Adjustable range (Å)	Turning angle of grating
Sodium fluorescein	2.8×10^{-3}	5350 5750	1°44'
Rhodamine 6G	1.2×10^{-3}	5750 6200	1°50'
Rhodamine B	2.0×10^{-3}	5950 6350	1°26'
Methyl phenol purple	4.2×10^{-3}	6450 7000	

Measuring error is ± 20Å.

4. Impact of Dye Density on Adjustable Range

The oscillatory wave length of dye laser will vary according to the length of dye box, dye density, temperature and the lost in resonant cavity. If the dye box, resonant cavity and temperature are fixed, when dye density is changing, such phenomena can be discovered as the density is increasing, and the maximum oscillatory wave length moves toward the longer wave; when density is reduced, it moves toward the shorter wave. And there is a density, which can make the adjustable range the largest.

The result of experiment of the relationship between the density of rhodamine 6G and sodium fluorescein and the adjustable ranges can be seen in Table 2 and Diagram 3.

Table 2

Dye	Density	Adjustable ranges (Å)	Dye	Density	Adjustable ranges (Å)
Rhodamine 6G	3.1×10^{-3}	6000~5930	Sodium flrorescein	1.1×10^{-3}	5670~5450
	1.0×10^{-3}	6000~5850		2.3×10^{-3}	5810~5520
	4.8×10^{-3}	6050~5770		4.6×10^{-3}	5550
	1.2×10^{-3}	6200~5750		5.7×10^{-3}	5730~5450
	6.0×10^{-4}	6100~57?0		2.9×10^{-3}	5750~5100
	3.9×10^{-4}	6000~5650		1.4×10^{-3}	5650~5350
	1.5×10^{-4}	5850~5800			
	7.5×10^{-5}	No oscillation			

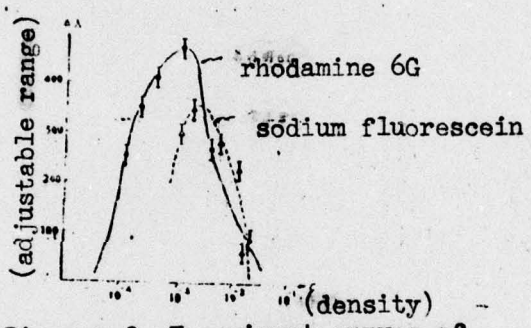

Diagram 3 Experiment curves of density and adjustable ranges.

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